METRICS WHICH ENCOURAGE P2
for consideration in determining MACT or alternative limits

The following metrics may encourage pollution prevention when expressed alone as a MACT limit, when used as an equivalent limit in combination with a traditional (concentration-based) limit, or as an alternative compliance limit:

1) Mass emissions / Time
2) Mass emissions / Energy output
3) Mass emissions / Heat input
4) Mass emissions / Fuel or waste input
5) Mass emissions / Unit of production
6) Mass emissions / Volume

The document analyzes various combinations of mass, input, output, and time measurements, combined to create different "metrics" for MACT limits. This analysis explores the likely effects on sources and the emissions of regulated pollutants by examining the possible responses of the regulated community to each metric.

NOTES:

- The ICCR regulation requires that emission limits be applied to a single device, rather than to a whole facility. Some of the metrics may not be useful in this context. For example, using a metric based on emissions per "widget" production requires that a certain percentage of total widget production can be associated with a specific combustion device in a facility. This in turn requires that each device's percent contribution be static.

- Each option may not necessarily be ideal for MACT alone or an alternative alone. Characteristics should be reviewed to consider the most applicable use for a particular source that effectively encourages prevention.

Also provided are non-consensus informational appendices: Appendix I. summarizes the applicability of each metric to different prevention approaches and places each metric in the context of the Subgroup's input, device and output table; Appendix II. indicates some of the prevention characteristics and biases associated with each metric, whether certain metrics are appropriate for use as MACT standards and what measures or data may be necessary to support the selection of such a metric; and Appendix III. presents examples of how each metric can be used and how compliance can be demonstrated

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APPENDIX I.

Metrics Overview Table

The table below summarizes the potential various outcomes encouraged by the different metrics. The outcomes are further elaborated upon in the *"CHARACTERISTICS"* section of each Metric description.

	APPLICABILITY					
	Control Devices	Fuel Pretreatment	Switch to Cleaner Fuels	Good Combustion Practices	Improve Conversion Efficiency in Device	Demand-Side Energy Conservation & Process Efficiency
mass emissions/ time	✔	✔	✔	✔	✔	✔
mass/ energy output	✔	✔	✔	✔	✔	
mass/ heat input	✔	✔	✔	✔		
mass/ fuel, waste input	✔	✔	✔	✔		
mass/ unit of production	✔	✔	✔	✔	✔	✔
mass/ volume	✔	✔	✔	✔		

<u>Impact of Metrics on Input, Device or Output</u>

The table below summarizes whether a particular metric will have an effect on the input side (e.g. fuel/waste), the device itself (e.g. improved conversion efficiency) or the output side (e.g. energy conservation). These designations coincide with the groupings formed by the P2 Subgroup.

	Input	**Device**	**Output**
mass emissions/ time	✔	✔	✔
mass/ energy output	✔	✔	
mass/ heat input	✔		
mass/ fuel, waste input	✔		
mass/ unit of production	✔	✔	✔
mass/ volume	✔		

APPENDIX II.

NON-CONSENSUS -- INFORMATIONAL

Description of Metrics

Note: This Appendix is a non-consensus document of the Pollution Prevention Subgroup. As such, it represents different points of view, and may contain conflicting statements under "Characteristics".

METRIC #1: Mass emissions per time interval (e.g. lbs/hour, or other units as appropriate)

CHARACTERISTICS:

- may promote the use of control technologies, good combustion practices, fuel switching, fuel pretreatment, conversion efficiency improvements of the device, or more efficient use of energy.

- limits the absolute amount of emissions released to the environment.

- this metric is size/capacity specific and therefore may be difficult or impossible to use as a MACT standard.

- Doesn't reflect changes in production levels.

DATA NEEDED:

- emissions of regulated pollutants, in mass units (lbs/hr, or other units as appropriate).

- operating hours (if limit is in lbs/yr).

METRIC #2: Mass per energy output (lbs of emissions / Btu of energy output)

CHARACTERISTICS:

- measuring output energy is complex.

- may promote the use of control technologies, good combustion practices, fuel switching, fuel pretreatment, or improvements in the energy efficiency of the device.

- does not limit the absolute amount of emissions released, since the emissions in the numerator varies proportionally with energy output in the denominator.
- does not directly encourage energy conservation.

- does encourage greater conversion efficiency (e.g. cogeneration).

- discourages use of wood with higher moisture content (which may instead go to landfills).

DATA NEEDED:

- energy output from device (Btu/hr).

- emissions of regulated pollutants, in mass units (lbs/hr, or other units as appropriate).

METRIC #3: Mass per heat input (lbs of emissions / Btu of fuel input)

CHARACTERISTICS:

- may promote the use of control technologies, good combustion practices, fuel switching, or fuel pretreatment.

- does not limit the absolute amount of emissions released, since the limit is based on emissions relative to input energy (i.e., allows more emissions if burning more fuel).

- does not encourage burning less fuel, therefore does not encourage greater efficiency or energy conservation.

DATA NEEDED:

- emissions of regulated pollutants, in mass units (lbs/hr, or other units as appropriate.

- heat content of fuel inputs (Btu/lb).

- quantity of fuel.

METRIC #4: Mass per unit of waste/fuel (e.g. lbs of emissions / ft^3 of waste)

CHARACTERISTICS:

- may promote the use of control technologies, good combustion practices, fuel switching, or fuel pretreatment.

- does not limit the absolute amount of emissions released, since the emissions figure in the numerator varies proportionally with fuel input (i.e., allows more emissions if burning more fuel).

- does not encourage energy conservation.

DATA NEEDED:

- emissions of regulated pollutants, in mass units (lbs/hr).

- amount of fuel input (ft^3/hr-gas; gal/hr- liquid; tons/hr-coal).

METRIC #5: Mass per unit of production (lbs of emissions / widget, unit of service (for non-manufacturing sectors), $, job, etc.)

CHARACTERISTICS:

- may promote the use of control technologies, good combustion practices, fuel switching, fuel pretreatment, conversion efficiency improvements of the device, or more efficient use of energy in manufacturing.

- does not limit the absolute amount of emissions released to the environment, since HAP emissions can increase with production increases.

- requires some way to quantify "unit of production" and to associate that with a particular combustion source within a facility.

- due to differences in energy consumption per unit of production, may be difficult to do as a MACT but rather as an alternative.

DATA NEEDED:

- emissions of regulated pollutants, (lbs/hr and hrs/yr).

- annual production figures, or a surrogate.

METRIC #6: Stack concentration (mg/m^3 for particulates, ppmv for gaseous)

CHARACTERISTICS:

- this metric is a common method to measure emissions at the stack.
- relatively easy to measure.
- does not directly encourage pollution prevention or energy conservation.
- does not reflect total mass loadings to the environment.
- emissions are not associated with any variables that account for source reduction.
- does not limit the absolute amount of emissions released to the environment, since mass can increase with increased air flow.

DATA NEEDED:

- concentration in ppmv for gaseous .

  or

- emissions in milligrams per Nm^3 and exhaust gas flow rate in cubic meters for particulates.

Appendix III.

NON-CONSENSUS -- INFORMATIONAL

Examples of P2 Metrics

This section contains an example for the metrics, which walks through all the possible responses of a combustion device operator to emission limits set each way. Below are the current operating conditions of the hypothetical combustion device used in the examples. *The units used here are for illustration purposes only.*

Production:	**1 widget/hr**
Input Fuel:	**10,000 ft^3/hr**
Heating Value:	**10 million Btu_{in}/hr**
Energy Output:	**8 million Btu_{out}/hr**
Current emissions:	**1 lbs/hr of regulated pollutant**

METRIC OPTIONS:

Metric #1: Mass emissions / time
Metric #2: Mass emissions / energy output
Metric #3: Mass emissions / heat input
Metric #4: Mass emissions / fuel or waste input
Metric #5: Mass emissions / unit of production
Metric #6: Stack concentration*

*no example provided

EXAMPLE 1: Mass emissions per time interval

Mass per time ratio- current: 1 lb/hr of regulated pollutant

Mass per time ratio- new limit: 0.95 lbs/hr of regulated pollutant (5% reduction)

Ways to get from current ratio to new limit:

- **Use control devices** to capture emissions generated from device.
  Amount of fuel input and emission generation at the device remain constant.

- **Use better combustion practices** to reduce emissions generated from device.
  Amount of fuel input remains constant.

- **Pretreat fuel** to reduce pollutant content, so that fuel burning generates fewer emissions.
  Amount of fuel input remains constant.

- **Switch to a cleaner fuel** (lower pollutant content) so that combustion generates fewer emissions.

  Amount of fuel input is indeterminate, varying with relative heat value; if the new fuel's heating value is greater, then total fuel consumption decreases. If the heating value is lower, the total fuel consumption increases.

- **Increase the conversion efficiency of the device,** so that you don't have to burn as much fuel to satisfy the same energy demand. Burning less fuel will lower the accompanying emissions**.**

  Analysis: If production remains stable at 1 widget/hr, then, barring any widget-production changes, energy demands will remain stable at 8 million Btu_{out}/hr. However, a higher conversion efficiency would lower fuel input requirements.

Conversion Efficiency:	$[Btu_{out}] / [Btu_{in}]$ = [Conversion Efficiency]
Current Conv. Eff.:	[8 million Btu_{out}] / [10 million Btu_{in}] = [80%]
Higher Conv. Eff.:	[8 million Btu_{out}] / X = [84.21%]
	===> X = **9.5 million Btu_{in}**

  This fuel input reduction (from 10 to 9.5 million Btu_{in}/hr) results in a reduction in emissions. Before, we saw that 10 million Btu_{in}/hr fuel input resulted in 1 lb of emissions/hr. Assuming that the *rate* of emission generation will be the same, we can see what the emissions are with the reduced fuel inputs.

$$\frac{9.5 \text{ million Btu}_{in}}{\text{hr}} \times \frac{1 \text{ lb of regulated pollutant/hr}}{10 \text{ million Btu}_{in}\text{/hr}} = 0.95 \text{ lbs/hr}$$

This satisfies the new limit.

- **Make more efficient use of energy output**, in order to reduce energy demand over time, thereby reducing the amount of fuel input over time, and thus reducing emissions.
  Analysis: Reducing required energy output over time from 8 to 7.6 million Btu/hr will reduce the amount of fuel inputs needed from 10 to 9.5 million Btu_{in}/hr.

  Btu_{out}-to-Btu_{in}: [Btu_{out}] / [Conversion Efficiency] = [Btu_{in}]
  Current ratio: [8 million Btu_{out}/hr] / [80%] = 10 million Btu_{in}/hr
  New ratio: [7.6 million Btu_{out}/hr] / [80%] = 9.5 million Btu_{in}/hr

  This fuel input reduction (from 10 to 9.5 million Btu_{in}/hr) will result in the required reduction in emissions. Before, we saw that 10 million Btu_{in}/hr fuel input resulted in the generation of 1 lbs/hr of pollutant. Assuming the *rate* of emission generation will be the same, we can see what the emissions/hr will be with the reduced fuel inputs.

$$\frac{9.5 \text{ million Btu}_{in}}{\text{hour}} \times \frac{1 \text{ lbs of pollutant}}{10 \text{ million Btu}_{in}} = 0.95 \text{ lbs/hr}$$

  This satisfies the limit.

  More efficient use of energy output can be accomplished through process-wide pollution prevention and facility-wide energy conservation.

EXAMPLE 2: Mass per energy output

Mass per energy output ratio- current: $\frac{1 \text{ lbs of regulated pollutant/hr}}{8 \text{ million Btu}_{out}\text{/hr}} = \mathbf{1.25 \times 10^{-7}}$

Mass per energy output ratio- new limit: $\frac{0.95 \text{ lbs of regulated pollutant/hr}}{8 \text{ million Btu}_{out}\text{/hr}} = \mathbf{1.1875 \times 10^{-7}}$

Ways to get from current ratio to the limit:

- **Use control devices** to reduce emissions by 5% (from 1 to 0.95 lbs/hr).
  Amount of fuel input and emission generation at the device remain constant.

- **Use good combustion practices** to reduce emission generation at the device by 5%.
  Amount of fuel input remains constant.

- **Pretreat fuel** to reduce pollutant content of fuel by 5%.
  Amount of fuel input remains constant; emission generation at the device reduced by 5%.

- **Switch to a cleaner fuel** to reduce pollutant content of fuel by 5%.

  Amount of fuel input is indeterminate, varying with relative heat value; if the new fuel's heating value is greater, then total fuel consumption decreases. If the heating value is lower, the total fuel consumption increases.
  Emission generation at the device decreases by 5%.

- **Increase the conversion efficiency of the device,** so that you don't have to burn as much fuel to satisfy the same energy demand. Burning less fuel will lower the accompanying emissions**.**

  Analysis: If production remains stable at 1 widget/hr, then, barring any changes in widget production, energy demands will remain stable at 8 million Btu_{out}/hr. However, a higher conversion efficiency would lower fuel input requirements.

  Conversion Efficiency: $[Btu_{out}] / [Btu_{in}] = [\text{Conversion Efficiency}]$
  Current Conv. Eff.: $[8 \text{ million } Btu_{out}] / [10 \text{ million } Btu_{in}] = [80\%]$
  Higher Conv. Eff.: $[8 \text{ million } Btu_{out}] / X = [84.21\%]$
  $\Longrightarrow X = \mathbf{9.5 \text{ million } Btu_{in}}$

  This fuel input reduction (from 10 to 9.5 million Btu_{in}/hr) results in a reduction in emissions. Before, we saw that 10 million Btu_{in}/hr fuel input resulted in 1 lb/hr.

  Assuming that the *rate* of emission generation will be the same, we can see what the emissions are with the reduced fuel inputs.

$$\frac{9.5 \text{ million } Btu_{in}}{\text{hr}} \times \frac{1 \text{ lbs of regulated pollutant}}{10 \text{ million } Btu_{in}} = 0.95 \text{ lbs/hr}$$

  So the new mass per energy output ratio is as follows:

$$\frac{0.95 \text{ lbs of regulated pollutant/hr}}{8 \text{ million } Btu_{out}/\text{hr}} = \mathbf{1.1875 \times 10^{-7}}$$

  This satisfies the new limit.

EXAMPLE 3: Mass per heat input

Mass per heat input ratio- current: $\frac{\text{1 lbs of regulated pollutant/hr}}{\text{10 million Btu}_{in}\text{/hr}}$ = **1x10^{-7}**

Mass per heat input ratio- new limit: $\frac{\text{0.95 lbs of regulated pollutant/hr}}{\text{10 million Btu}_{in}\text{/hr}}$ = **0.95x10^{-7}**

Ways to get from current ratio to the limit:

- **Use control devices** to reduce emissions by 5% (from 1 to 0.95 lbs/hr).
  Amount of fuel input and emission generation at the device remain constant.

- **Use good combustion practices** to reduce emission generation by 5%.
  Amount of fuel input remains constant.

- **Pretreat fuel** to reduce pollutant content of fuel by 5%.
  Amount of fuel input remains constant. Emission generation decreases by 5%.

- **Switch to a cleaner fuel** to reduce pollutant/Btu content by 5%.

  Amount of fuel input is indeterminate, varying with relative heat value. If the cleaner fuel's heat value is greater , then total fuel consumption decreases, and emission generation decreases by 5%.

EXAMPLE 4: Mass per fuel input

Mass per fuel input ratio- current: $\frac{\text{1 lbs of regulated pollutant/hr}}{\text{10,000 cubic ft}_{in}\text{/hr}}$ = **1x10^{-4}**

Mass per fuel input ratio- new limit: $\frac{\text{0.95 lbs of regulated pollutant/hr}}{\text{10,000 cubic ft}_{in}\text{/hr}}$ = **0.95x10^{-4}**

Ways to get from current ratio to the limit:

- **Use control devices** to reduce emissions by 5% (from 1 to 0.95 lbs/hr).
  Amount of fuel input and emission generation at the device remain constant.

- **Use good combustion practices** to reduce emission generation by 5%.
  Amount of fuel input remains constant.

- **Pretreat fuel** to reduce pollutant content of fuel by 5%.

Amount of fuel input remains constant. Emission generation decreases by 5%.

- **Switch to a cleaner fuel** to reduce pollutant content by 5%.

  Amount of fuel input is indeterminate, varying with relative heat value; if the cleaner fuel's heat value is greater, then total fuel consumption decreases. Emission generation decreases by 5%.

<u>EXAMPLE 5: Mass per unit of production</u>

Mass per widget ratio- current: $\dfrac{\text{1 lb of regulated pollutant/hr}}{\text{1 widget/hr}} = \text{1 lb/widget}$

Mass per widget ratio- new limit: $\dfrac{\text{0.95 lbs of regulated pollutant/hr}}{\text{1 widget/hr}} = \text{0.95 lbs/widget}$

Ways to get from current ratio to the limit:

- **Use control devices** to capture emissions generated from device.
  Reduce emissions by 5% (from 1 to 0.95 lbs/hr).
  Amount of fuel input and emissions at the device remain constant.

- **Use better combustion practices** to reduce emissions generated from device.
  Reduce emissions at the device by 5% (from 1 to 0.95 lbs/hr).
  Amount of fuel input remains constant.

- **Pretreat fuel** to reduce pollutant content, so that fuel burning generates fewer emissions.
  Reduce pollutant content of fuel by about 5% to achieve a 5% reduction in emissions.
  Amount of fuel input remains constant.

- **Switch to cleaner fuel**, (lower pollutant content) so that combustion generates fewer emissions.

  Amount of fuel input is indeterminate, varying with relative heat value; if the new fuel's heating value is greater, then total fuel consumption decreases. But if the heating value is lower, the total fuel consumption increases.

- **Increase the conversion efficiency of the device,** so that you don't have to burn as much fuel to generate the same amount of energy. This will reduce fuel burning requirements while satisfying the same energy demand. Burning less fuel will lower the accompanying emissions**.**

Analysis: If production remains stable at 1 widget/hr, then, barring any widget-production changes, energy demands will remain stable at 8 million Btu_{out}/hr. However, a higher conversion efficiency would lower fuel input requirements.

Conversion Efficiency:	$[Btu_{out}] / [Btu_{in}]$ = [Conversion Efficiency]
Current Conv. Eff.:	[8 million Btu_{out}] / [10 million Btu_{in}] = [80%]
Higher Conv. Eff.:	[8 million Btu_{out}] / X = [84.21%]
	===> X = 9.5 million Btu_{in}

This fuel input reduction (from 10 to 9.5 million Btu_{in}/hr) results in a reduction in emissions. Before, we saw that 10 million Btu_{in}/hr fuel input resulted in 1 lb/hr. Assuming that the *rate* of emission generation will be the same, we can see what the emissions are with the reduced fuel inputs.

$$\frac{9.5 \text{ million } Btu_{in}}{\text{hr}} \times \frac{1 \text{ lb of regulated pollutant/hr}}{10 \text{ million } Btu_{in}/\text{hr}} = 0.95 \text{ lbs/hr}$$

So the new mass per unit of production ratio is as follows:

$$\frac{0.95 \text{ lbs of regulated pollutant/hr}}{1 \text{ widget/hr}} = 0.95 \text{ lbs/widget}$$

This satisfies the limit.

Make more efficient use of energy output by using less energy per widget, in order to reduce energy demand over time, thereby reducing the amount of fuel input over time, and thus reducing emissions. Widget production stays the same while emissions go down, thus satisfying the limit.

Currently, energy required per widget produced is 8 million Btu_{out}/widget:

$$\frac{8 \text{ million } Btu_{out}/\text{hr}}{1 \text{ widget/hr}} = 8 \text{ million } Btu_{out}/\text{widget}$$

But suppose we can make the widget production process 5% more efficient, allowing us to require only 7.6 million Btu_{out}/widget.

$$[8 \text{ million } Btu_{out}/\text{widget}] \times [95\%] = 7.6 \text{ million } Btu_{out}/\text{widget}$$

Reducing energy output over time from 8 million to 7.6 million Btu/hr will reduce the amount of fuel inputs needed from 10 to 9.5 million Btu_{in}/hr.

$$[Btu_{out}] / [\text{Conversion Efficiency}] = [Btu_{in}]$$

$$[7.6 \text{ million } Btu_{out}/hr] \;/\; [80\%] = 9.5 \text{ billion } Btu_{in}/hr$$

This fuel input reduction (from 10 to 9.5 million Btu_{in}/hr) results in a reduction in emissions. Before, we saw that 10 million Btu_{in}/hr fuel input resulted in 1 lb of regulated pollutant emissions/hr. Assuming the *rate* of emission generation will be the same, we can see what the emissions/hr will be with the reduced fuel inputs.

$$\frac{9.5 \text{ million } Btu_{in}}{\text{hour}} \times \frac{1 \text{ lb of pollutant/hr}}{10 \text{ million } Btu_{in}/hr} = 0.95 \text{ lbs/hr}$$

This satisfies the limit.

More efficient use of energy output can be accomplished through process-wide pollution prevention and facility-wide energy conservation.